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OCCUPATIONAL HEALTH HAZARDS OF EXPOSURE TO 1,3-DICHLOROPROPENE

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SUMMARY

The chemical, 1,3-dichloropropene, is an active ingredient of a number of agricultural pesticides used as fungicides and nematocides. Several million pounds are injected into the soil of several thousand acres of fields in California and throughout the world each year. Skin and eye contact with this chemical can and does result in severe irritation reactions in exposed persons. Inhalation can lead to anesthesia, chemical pneumonia, and pulmonary hemorrhage. It appears that very substantial skin and/or inhalation exposure under special circumstances such as occur following an accidental spill can also lead to effects upon the central nervous system resulting in severe headaches, irritability, easy fatiguability, anxiety, hyperactivity, fearfulness, loss of sex drive, and other behavioral changes. It appears that the hazards of use and how to avoid them need to be more explicitly described on the pesticide labels. It appears that State and Federal Department of Transportation regulations may need amendments to more adequately reflect the high hazard of exposure to this chemical by inhalation and skin contact. Present regulations and label instructions appear to be based only upon the lower hazard of oral ingestion and flammability.

INTRODUCTION

The chemical, 1,3-dichloropropene, is known to cause skin and eye irritation on direct contact, and pulmonary damage upon inhalation, but nothing has been reported in the literature concerning its acute and delayed toxic effects on the central nervous system. The chemical structure of the compound, 1,3-dichloropropene, suggests that it would have anesthetic properties; and one author (Dr. Peoples) synthesized it in 1933 along with similar chlorinated hydrocarbons, to evaluate it as a possible anesthetic. Tests with this substance proved that the anesthetic dose also caused death in the animals due to lung irritation and it was quickly abandoned as a practical anesthetic agent. The work was not published.

The chemical, 1,3-dichloropropene, is an effective pesticide ingredient, particularly as a nematocide and it is injected into soil prior to planting a number of crops. It is used in large quantities in California and is present in significant quantities in 56 different pesticides that were registered for use in California in 1975. Human illnesses of all types reported in California in 1974 and 1975 due to exposure to pesticides that contain this chemical involved only: D-D, Telone, Telone C, and Telone II. Apparently central nervous system damage occurred in one person following spill of one pint of Telone on his sleeve and arm in 1972 and to a number of persons following exposure to a large highway spill of Telone II in 1975.

The general effects of this chemical on the skin, eyes and lungs will be briefly described.

The two spills causing human exposure to Telone and Telone II with possible central nervous system effects will be reviewed in depth in this report to determine if those exposed have suffered acute or chronic damage to the nervous system and if so, how can such exposures be prevented.

COMPOSITION AND PHYSICAL PROPERTIES OF A TYPICAL PESTICIDE CONTAINING 1,3-DICHLOROPROPENE

Composition	
Cis-1, 3-dichloropropene	54% (B.P. 105°C)
Trans-1, 3-dichloroprepene	29% (B.P. 112°C)
Trans-2, 3-dichloropropene	9%
Trans-2, 2-dichloropropane	7%
Epichlorhydrin	1%
	100%

Physical Properties	
Boiling point	109°C
Vapor pressure at 20°C	33mm
Density	1.22
Vapor Density	3.83
Flash Point	70°C

It is inflammable yielding HCl. Under certain circumstances, heat will cause the formation of phosgene.

TOXICITY STUDIES

Studies by Dow Chemical Company of single exposures of male rats to the vapors of 1,3-dichloropropene were conducted from levels of 9,700 ppm down to 700 ppm. All rats died when exposed for more than an hour to levels above 1,000 ppm. At 700 ppm for two hours, although death did not occur, severe lung hemorrhages and moderate liver damage was observed in exposed rats. The Dow Chemical Company concluded that "1,3-dichloropropene presents a definite hazard from inhalation. Concentrations capable of causing death or serious injury in a few minutes are readily attained at room temperature. Design of equipment and procedures must be such that exposure cannot occur. The material has a moderate acute oral toxicity and is capable of causing severe damage to the eyes. It has a severe vesicant action upon the skin. Common type protective equipment, such as rubber gloves and vinyl boots are apparently readily penetrated by this material. Care must be exercised in selecting proper material." "At any time 1,3-dichloropropene contacts rubber or neoprene gloves, they should be removed and discarded. This material penetrates rubber and neoprene." "Polyethylene provides a good barrier. For field operations, cover shoes and hands with polyethylene bags."

Acute dermal toxicity studies by the Dow Chemical Company show that 1,3-dichloropropene is quite irritating to the skin, causing edema, redness and necrosis. When applied 24 hours under a cuff, as a 12.5% solution in propylene glycol, the material was absorbed through the skin of rabbits in lethal amounts with deaths occurring from doses of 125 to 250 milligrams per kilogram.

SUMMARY OF TOXICITY STUDIES IN ANIMALS ON 1,3-DICHLOROPROPENE

Toxicity studies in animals conducted by Dow Chemical Company were in connection with their requesting registration of Telone and Telone II by the California Department of Food and Agriculture for use in California. The following data were taken from these reports:

Acute Oral Toxicity in Rats. Vehicle corn oil

250 mg/Kg	0/2 died	lung hemorrhage, fatty liver
500 mg/Kg	2/2 died	severe lung hemorrhage, fatty liver

Subacute Oral Toxicity in Rats (28 day) Vehicle not noted.

30 mg/Kg	no deaths
90 mg/Kg	no deaths, pathological changes in liver and kidney

Subactue Oral Toxicity in Rats (90 day) Vehicle propylene glycol

10-30 mg/Kg	no deaths, no pathology

Dermal Toxicity undiluted on rabbit belly

1 hour exposure -- severe edema and hyperemia, slight necrosis
5 minutes exposure -- severe edema, slight hyperemia, exfoliation

Dermal Absorption 12.6% in propylene glycol on rabbit belly

500 mg/Kg	2/2 died	skin badly burned, moderate edema
250 mg/Kg	1/2 died	skin burned

Eye Irritation rabbit

Undiluted, unwashed	Severe pain, severe conjunctival irritation, corneal damage, no healing in a week
Undiluted, washed with water	Slight pain, severe conjunctival irritation, corneal damage with healing in a week.

Inhalation - single exposure in rats

2700-9700 ppm	0.5 hr.	All died after removal
1000 ppm	2 & 4 hrs.	Immediate eye irritation, unconscious, all died after removal. Severe liver and kidney damage.
1000 ppm	0.5 - 1.0 hrs.	Drowsy, no pathology, no deaths
700 ppm	2 & 4 hrs.	Drowsy, eye irritation, lung hemorrhages, fatty liver, no deaths

Conclusions

Pesticides containing 1,3-dichloropropene have a low acute and subacute oral toxicity. Dermal irritation is severe but passed DOT standards as being non-corrosive. Prolonged dermal contact with between 250 and 500 mg/Kg produces sufficient skin absorption to cause death to test rabbits. Those pesticides are a severe eye irritant, producing pain, inflammation and corneal damage unless washed out with water. Inhalation causes central nervous system depression from drowsiness to anesthesia, depending on the concentration. They are a severe irritant to the eyes and lungs which may develop hemorrhages.

USUAL PATTERN OF OCCUPATIONAL ILLNESSES FROM EXPOSURE TO 1,3-DICHLOROPROPENE

Over the past six years, physician's reports to the Department of Industrial Relations of the State of California concerning occupational exposure to pesticides containing 1,3-dichloropropene have averaged about 10 to 15 cases per year. Thirty-three of the cases reported during 1974 and 1975 are summarized below:

Analysis of Physicians' Reports Filed During 1974 and 1975 on Pesticide Related Illnesses Due to Exposure to Pesticides Containing 1,3-Dichloropene (with the Sutter County October 1975 spill incident excluded).

Nature of Injury	Number of Cases
*Systemic (chest pain)	6
Skin irritation	8
Eye irritation	10
Skin and eye irritation	7
Allergy	2
TOTAL	33

*These cases caused irritation of the nasopharynx without central nervous system effect.

THE SPILL INCIDENTS THAT APPEAR TO HAVE LED TO CENTRAL NERVOUS SYSTEM EFFECTS IN SOME OF THE EXPOSED PERSONS

The balance of this report will focus on two pesticide spill incidents; one in 1972 and another in 1975 that appear to have resulted in effects upon the central nervous system of the persons exposed.

The Accidental Exposure of a Workman to Telone at the Pittsburg Plant of The Dow Chemical Company

On November 16, 1972, a structural steel worker made accidental contact by his shoulder rolling open a tank drainage valve with a stream of about one pint of Telone coming from a pipe from a supply tank which saturated one sleeve. Without removing his contaminated clothing, he was taken to a hospital where he waited over an hour before being treated. He was found to have irritation of the skin, eyes and nose. He was never unconscious, and had normal sensory and reflex activity. Subsequently he was given extensive examinations including repeated liver and kidney tests, but all were negative except for an occasional cardiac arrythmia which was not considered to be abnormal. He gradually, during the next several weeks, developed a change in personality in that he became anxious, fearful, and developed hyperventilation and sweating of the palms when under the slightest stress. A physician-toxicologist, examined him and found that this worker had feelings of depersonalization and anxiety but wasn't sure it was due to the effects of the Telone or fright due to the accident. Prior to the exposure, this worker had been considered an unusually fearless structural steel worker; after the incident he was afraid to stand on a chair or to be left in a room alone.

This steel worker was given an out-of-court settlement on October 28, 1975, but this apparently had little effect on his health. He has been examined by a psychologist who convinced him that his condition was nervousness and not due to the toxic effects of Telone. He soon lost faith in this advice after trying to go back to work. He was said to have shaken uncontrollably and to have sweat considerably when he tried to work again.

One of us, Dr. Peoples, had a telephone conversation with the steel worker's personal physician on April 23, 1976. The physician stated that the worker now considers himself completely disabled and has given up trying to get a job. He sits around the house doing nothing. He blames his condition, which is physical weakness and inability to concentrate, on the exposure to Telone. He states that his ability to perform sexually was eliminated by the Telone exposure. His wife says she does not think he will ever recover. His personal physician states that he is not sure now whether the exposure to Telone caused these adverse health effects by its toxic effects on the higher centers of the brain or triggered a psychological change that would have happened anyway.

The Telone II Spill Near Yuba City, California, on October 21, 1975

At 8:40 a.m. on October 21, 1975, eight miles west of Yuba City, California, there was a collision between a truck pulling a travel trailer and a truck tractor pulling a trailer carrying a tank containing about 1,200 gallons of Telone II. The tractor separated from the trailer and the tank broke loose

from the trailer and ruptured, slowly pouring Telone II over the highway, the side of the road, and on the wreckage of the travel trailer. Forty feet away, the truck tractor lay on its side on fire, but fortunately the inflammable liquid, Telone II, around the trailer did not ignite.

The California Highway Patrol (CHP) and the Yuba City and Sutter County fire departments responded to handle traffic, fight the fire, hose the Telone II from the highway, and to clear the wreckage. A Sergeant of the CHP then in charge could not identify the contents of the tank from the labels still visible on the wrecked vehicles, but was correctly informed by the truck driver that Telone II was the liquid being hauled. The Highway Patrol contacted Chemtrec through the Chico Dispatch Center at 9:02 a.m. and was told by Chemtrec that Telone II could cause skin irritation, dizziness and nausea, but that it was not a hazardous substance. It was not until 11:51 a.m. that the CHP received the information furnished by the Dow Chemical Company by telephone that Telone II could be dangerous on inhalation; full self-contained face masks were needed, that it attacked leather and rubber so that boots and shoes must be discarded after contact with the liquid and that the only resistant material to protect the skin was polyethylene.

By 11:61 a.m., five CHP had been exposed to the liquid and vapor without any protective clothing. The firemen had been wearing full protective clothing including self-contained face masks most of the time.

Whether due to penetration of Telone II through the rubber of the protective clothing, exposure of unprotected skin, or removal of the mask for some reason, such as empty air tanks, one fireman fell unconscious at 10:51 at the accident scene and had convulsions. At 11:54 a second fireman and then a third fireman also fell unconscious and had convulsions at the accident scene. These three men were taken to the Sutter General Hospital for treatment. It was then recommended that all persons who had been at the scene of the accident should report to the Sutter General Hospital for examination.

The number of persons exposed was estimated at 80, but only 45 Pesticide Illness Reports were eventually received by the State Department of Health. One physician submitted (the first physician) 20 "outpatient" reports, and a second physician submitted 25 "inpatient" reports. Except for identifying the patient, the reports written by the second physician were identical: major signs and symptoms were listed as "respiratory distress, itching, nausea." Similarly, each of the first physician's reports listed under signs and symptoms "checked for symptoms."

In all, 21 cases were admitted to the hospital by both physicians and were treated with saline wash for eye irritation and soap and water shower for skin irritation. All cases were discharged on the following day with arrangements made for follow-up examinations. The CHP cases were then taken care of by a third physician and some others were cared for by other private physicians in the area.

Two of us (Dr. Peoples and William Thomas) interviewed the first physician on November 10, 1975, and learned that in the follow-up period two cases had skin rash of short duration, several had persistent headaches and that

one case under the care of another physician had developed personality changes. This physician said that he planned more extensive tests on certain cases for liver and kidney function which would be complete by November 17, 1975.

In a telephone call to the first physician on November 17, 1975, (by Dr. Maddy) it was learned that of 36 patients seen in a follow-up visit on November 10, 1975, 16 were released from further follow-up. This first physician stated that he expected to release 10 of the remaining patients after the November 17, 1975, checkup. He said the patients no longer had eye and lung irritation symptoms but complained of nervousness, headache, malaise, indigestion and dyspepsia. Not all persons had all these symptoms. This physician said that he thought that the unusual pattern of symptoms that these patients exhibited and described indicated to him that he was dealing with real symptoms of illness.

On April 8, 1976, one of us (Dr. Peoples) talked by telephone with the second physician at the Sutter General Hospital as the first physician had moved away and was by then practicing medicine in Atlanta, Georgia. This second physician said he was then taking care of the firemen, one State of California Department of Transportation employee, and one described as an "emergency service employee." As several lawsuits are pending, this second physician declined to name the patients he and other physicians were then seeing, but he did describe the current symptoms of certain of the patients:

1. Two patients then had abnormal audiograms with defective hearing. Prior tests taken while in the army were said to have been normal.

2. One patient had acute trigonitis (bladder irritation) that the urologist attributed to Telone II exposure.

3. Most of the cases (number not mentioned) still had persistent headaches, irritability, and easy fatiguability.

4. One fireman's wife said that her husband's behavior had changed since the Telone II spill in that he couldn't sit still, had become hyperactive, and continued to show symptoms of anxiety. He was said to have shown signs of recent improvement.

This second treating physician said that he planned to continue to follow ten exposed individuals.

We reviewed our records of how the firemen themselves felt about the Telone II exposure and how it appeared to affect their health.

On December 11, 1975, we (William Thomas) conferred with the two senior firemen for Sutter County. Both men were said to have suffered the greatest exposure to Telone II at the scene of the accident, and both men said they still had symptoms of poisoning at that time. They said initially all the firemen exposed at the scene suffered skin rashes, anxiousness and irritability which was by then much less evident. They said ten men were having severe headaches and one man, a diabetic, was having serious fluctuations in his blood-sugar level.

On January 7, 1976, we (William Thomas) spoke to one of these senior firemen by telephone and was told that eight firemen still had moderate to severe headaches. He also said that he himself was being seen by the second physician because of a return of his nervousness. He said that this physician had recently also called in a California Department of Transportation employee who had been exposed at the spill scene because he had been showing symptoms of impairment of equilibrium on the job.

On April 8, 1976, we (Dr. Peoples) talked to one of these senior firemen who then told him that several firemen were still under the care of the second physician for "symptoms" which he declined to describe in more detail. He then gave the following account of his own health on that date:

1. He had experienced continuous headaches since the day of the accident.

2. He said he continued to feel "shaky, nervous and irritable." Tranquilizers gave temporary relief and he said that he "didn't want to depend on them the rest of his life."

3. He said that he "didn't have his previous stamina" and that he tired out when fighting fires as compared to good health prior to the Telone II exposure.

4. He said he had become intolerant of much smoke which recently had caused breathing difficulties at many recent fires due to a sensation of irritation in his chest.

He said that his assistant fireman had similar symptoms.

We (Dr. Peoples) asked this assistant about the report dated December 31, 1975, by one of the firemen in his summary of the Telone II chemical spill where two firemen tested the breathing apparatus used at the scene. The report stated: One fireman fell quickly unconscious and the second was made dizzy and nauseated. This assistant corroborated the incident except he said that the fireman was very dizzy and fell but he did not think that he became completely unconscious.

The exposed CHP men were given medical care by a third physician after their discharge from the Sutter General Hospital on October 22, 1975, and he turned in Doctor's First Report of Work Injury on four CHP officers. In each case the symptoms were tightness of the chest, headache, and eye irritation. Some records stated that there were harsh basal sounds in the chest and in the case of one there was a red edematous throat, not noted in the others.

On November 21, 1975, in a telephone conversation to us (Dr. Peoples), this third treating physician said that he eventually treated nine CHP men and was examining them at intervals to see if they developed delayed toxicity. He said that the acute symptoms were wheezing, a tight feeling in the chest, skin and eye irritation. He said some patients had experienced mental confusion for 24 hours after the exposure with loss of memory and difficulty in selecting proper words to carry on a conversation. After this cleared up, none had any residual mental problems or change in personality. He treated all the cases with steroids and antibiotics at the suggestion of a physician-toxicologist he had contacted in San Francisco. He had arranged

for laboratory tests for liver and kidney disfunction and although the SGOT was elevated for two to three days, he didn't think there was any significant liver damage. The BUN was normal in every case.

On December 5, 1975, in a letter from an official of the CHP to a chemical company physician, he stated:

> "Approximately two weeks following the incident, two of the firefighters involved conducted a test of their breathing apparatus. One quickly dropped unconscious and the other was considerably affected. Both were hospitalized again for a short time, then released. This symptom is interesting because I can find no reference in anyone's safety guides or labels concerning unconsciousness caused by these fumes, and this was the third such incident. And, of course, there was little or no dissipation of the Telone II fumes from the rubber masks on the air tanks. I don't know if they had been decontaminated.
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> "Apparently only one of my officers is still experiencing difficulty and he was by far the most severely affected during the incident. He still has an occasional period of discomfort but the prognosis is that he will fully recover. As the principal investigating officer, he was exposed to the Telone II more closely and for a longer duration than most others without protective clothing. His contact and subsequent problems are of interest because of so many inconsistencies (at least from the fireman's view). The fumes were not offensive or especially irritating at the scene, and he took little notice of them. Approximately one hour after leaving, his hands and face began to burn, but he didn't develop respiratory problems until two and one-half to three hours following exposure.
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> "However, from this point he had great pain and discomfort with every breath. This condition gradually cleared over the next two weeks much as recovery from pneumonia. The medication prescribed by his physician, acting on information "provided by Dr. ..... is clearly responsible for his continuing recovery."

On December 6, 1975, we (William Thomas) spoke with an official of the CHP who stated that one officer still seemed to show adverse effects of the Telone II exposure and has missed work.

On January 7, 1976, we (William Thomas) spoke with an official of the CHP who said that this officer has been returned to "full duty status" although he is being limited to daytime shifts so as "to monitor his job performance." He said this officer now has problems in relating to other persons on the job.

On April 8, 1976, we (Dr. Peoples) talked with a CHP official who stated that this officer had then been on "full duty status" for some time although he had some residual effects noted by how he related to other persons while on the job. This official did not seem to want to discuss

these problems with us (Dr. Peoples). All the other officers who were exposed were reported as in normal health and had no complaints as of that date.

We (Dr. Peoples) contacted the third physician by telephone on April 26, 1976, and asked about the present health of the CHP officers, and the one officer in particular. This physician told us that during the first two to four days (not 24 hours as previously stated) all the men suffered from mental changes characterized by irritability, loss of memory, and difficulty in finding the desirable words to carry on a conversation. This condition was not noted by the men while they were experiencing it, but was recalled separately by the men after the condition cleared up. These observations were also reported to this physician by some of the exposed men's wives. Other than the one man, he said, none of the men had had any mental or nervous problems since that time. This physician had examined all the men at three months post-exposure and six months post-exposure. He has used laboratory tests, X-rays and physical examinations to study this group of men and said that he was inclined to consider them all normal by April 1, 1976.

He then said that the one officer in question had had asthma problems when a child and it took him two weeks to get over the lung damage after the Telone II exposure incident. On April 20, 1976, this same officer came in to see him complaining about his lungs. This third physician gave him extensive pulmonary tests; the results were in the normal range. The officer also complained about a nervous condition which this physician described as "tension" and discounted its importance. He said it may not have been related to the Telone II exposure. This officer said his wife has not complained to him about this "tension" at any time.

It was clear that this third physician was not aware of the reason why this officer was put on duty with restrictions (daytime only so he could be monitored) until January or whether his alleged continuing nervousness or "tension" was related to it.

An official of the CHP Headquarters Personnel Office in Sacramento advised one of us (Dr. Peoples) on April 27, 1976, that he had on that date contacted an official of the Yuba City CHP office concerning current job performance of any patrolmen who had been exposed in the Telone II incident. This official said that only one of the CHP officers exposed at the Telone II spill was still having problems. This individual was said to have had some personality defects before the accident, but fellow officers now state that he has had a change in his personality since the exposure incident. They said he complained of severe headaches for several weeks after the accident but that he had not been complaining of them recently. This official then said at that time this officer had minimal difficulties in carrying out his assigned duties and had no serious health problems. This personnel official said that the local CHP official was trying to be as helpful as possible but was choosing his words very carefully in describing the officer's work performance.

DISCUSSION

A review of Doctor's First Report of Work Injury for 1974 and 1975 of injuries to workers exposed to pesticides containing 1,3-dichlorpropene, such as Telone, Telone II, Telone C, and D-D, indicate that the effects of modest exposure is to cause irritation of the skin, eyes, and respiratory tract. These modest injuries respond to treatment without residual effects or delayed toxicity.

In the two serious spill incidents described, several individuals were exposed to high concentrations of Telone and Telone II for a considerable length of time and showed both acute and delayed effects on the nervous system. Three men fell unconscious and had convulsions at the scene of the spill. The delayed effects were shown by many individuals who were dizzy for 24 hours and suffered severe headaches over several days and a few cases which have shown changes in personality characterized by anxiety, easy fatiguability, irritability, and sexual impotence.

The animal toxicity data indicate that the compound has the capability of causing chemical pneumonia and lung hemorrhage on prolonged inhalation to high concentrations. One individual at the Yuba City highway spill was diagnosed as having pneumonia lasting a week.

It appears that 1,3-dichloropropene, when inhaled or absorbed through the skin in sufficient amount, can produce serious acute and chronic toxicity to the nervous system. It appears that all the safety instructions for products containing this compound should include this warning; "If a spill occurs, do not enter the area without full protective clothing, and then only for short periods of time."

A change to a more restrictive DOT classification should be considered on the basis of the hazard of this chemical to respiration and effects on the central nervous system from inhalation or dermal exposure. It appears that the present classification reflects the more modest hazard of oral toxicity.

The labels of all the pesticides that contain 1,3-dichloropropene should take into account the possibilities of severely adverse effects upon human health in the event of substantial exposure of humans. The use precautions should advocate closed system handling. The fact that this chemical readily passes through rubber and vinyl and that polyethylene gloves and protective gear are needed, should be emphasized. The highly corrosive nature of this chemical to metal and all hoses except those made of polyethylene needs to be emphasized so that equipment deterioration and consequent human exposures can be minimized. The 45 labels of pesticides in use in California in 1975 that contain this chemical were reviewed; none were found to adequately reflect these hazards or how to prevent them.

Additional biologic studies of short-term and long-term effects of exposure to this chemical should be undertaken to evaluate its potential for damage to the central nervous system and the possible development of changes in behavior.